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Assessment of Rural Road Simulation Modelling Tools

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Abstract

Recent research investigated the relative merits of various simulation packages (in particular TRARR, TWOPAS and PARAMICS) for modelling vehicle interactions on rural highways in New Zealand. It assessed their suitability for use as tools for evaluations of crash risk and travel efficiency, particularly prediction of vehicle speeds and bunching in typical highway situations. All were found to have some strengths over the others for particular project applications. Further investigation is required, but it is recommended the use of different simulation packages on rural roading projects be encouraged.

1. Introduction

New Zealand relies largely on two-lane rural highways for its inter-regional land transport network. Many of these highways are less than optimal when considering consistency of speed environment, safety hazards, and minimisation of delays. To counter this, various ongoing improvements have been investigated, including realignments, passing-lanes, black-spot removal, and four-laning.

To assist in prioritising future upgrading work for funding, detailed simulation modelling is required to firstly identify sections requiring improvement and secondly to determine the likely effect of improvement projects. There is currently little guidance for analysts on the most suitable simulation tools available to use, and how to use them appropriately for various projects. Although more simplified procedures are being introduced to replace some simulation work and make things easier for both analysts and Transfund (e.g. passing lane procedures), there are limitations to the accuracy of this approach. Any move to further “simplified” methods will also still require research using simulation to confirm their validity for general use.

1.1 Research Outline

Opus Central Laboratories carried out research for Transfund New Zealand to investigate the relative merits of a number of different simulation packages for modelling vehicle interactions on rural highways (Koorey 2002). The main objectives of the research were:

- To identify suitable software packages for rural road simulation and assess their features.
- To compare the performance of different packages in assessing vehicle speed prediction, vehicle interaction, and relative crash risks.
- To consider the potential future application of such packages in New Zealand.

To meet these objectives, extensive literature was reviewed to identify the key performance measures of interest, and potentially suitable models available. Field survey data was then collected for assessing various packages, and the results analysed. For assessment of crash risk, a separate was made to identify promising evaluation tools. This paper focuses on the general assessment of simulation models. Further details on this and the other research objectives can be found in the related research report (Koorey 2002).

2. Rural Simulation Modelling Packages Available

A literature search was made of potentially suitable simulation modelling packages. One recent useful source of relevant information was the SMARTTEST project in Europe (ITS Leeds, 2000), the objective of which was to review existing micro-simulation models and identify gaps in situations modelled. The project however was very much focused on urban and freeway applications and interestingly did not identify two-lane rural simulation as a significant gap.

Based on this initial review, it was proposed to compare the following models for evaluating rural highways in terms of efficiency and safety:

- TRARR 4 software (ARRB Transport Research Ltd, Australia)
- TWOPAS 98 software (FHWA, US)
- PARAMICS 2001 software (SIAS Ltd, Scotland)

As well as a general assessment of each model, field data was also collected for calibrating and validating the models against real-life situations.

The three specified software packages were selected due to a combination of appropriateness and availability. Their attributes are discussed in more detail below. A number of similar models were also identified and are discussed in Section 2.4. However, difficulties in obtaining access to these models, coupled with the limited resources of this project, precluded further investigation for now. It is suggested that some of these be revisited in more detail at a later stage.

2.1 TRARR

At present, most detailed rural simulation in New Zealand is carried out using ARRB Transport

Research's TRARR software (Shepherd 1994), a microscopic simulation package. TRARR ("TRAffic on Rural Roads") was developed in the 1970s and 1980s by the Australian Road Research Board. Originally run on mainframe computer systems, the program was ported to a PC version (3.0) in 1986. The most recent version (4.0) was produced in 1994 and included a (DOS) graphical interface (albeit with reduced functionality) and the ability to import road geometry data for the creation of road sections. The latter greatly simplified the data creation requirements, particularly as New Zealand State Highways had been surveyed using ARRB's Road Geometry Data Acquisition System (RGDAS) in 1992. Figure 1 shows a screenshot from TRARR 4.

Figure 1 Screenshot from TRARR 4 Road Editor



TRARR is a micro-simulation model; i.e. it models each vehicle individually. Each vehicle is randomly generated, placed at one end of the road and monitored as it travels to the other end. Various driver behaviour and vehicle performance factors determine how the vehicle reacts to changes in alignment and other traffic. TRARR uses traffic flow, vehicle performance, and highway alignment data to establish, in detail, the speeds of vehicles along rural roads. This determines the driver demand for passing and whether or not passing manoeuvres may be executed.

TRARR is designed for two-lane rural highways, with occasional passing lane sections. As a result, it is ideal for modelling most of New Zealand's rural State Highway network. TRARR can be used to obtain a more precise calculation of travel time, frustration (via time spent following), and VOC benefits resulting from passing lanes or road realignments. For strategic assessment of road links, TRARR can also be used to evaluate the relative benefits of passing lanes at various spacing.

TRARR uses four main input files to describe the situation to be simulated:

- **ROAD:** the section of highway to be studied, in 100m increments. It includes horizontal curvature, gradient, auxiliary (passing) lanes, and no-overtaking lines.
- **TRAF:** the traffic volume and vehicle mix to be simulated. Other information regarding the simulation time and vehicle speeds is also contained here.
- **VEHS:** the operating characteristics of the vehicle fleet. The relevant details relating to engine power, mass, fuel consumption, and so on are entered into this file.

- **OBS:** the points along the highway at which to record data on vehicle movements. TRARR can provide a range of values including mean speed, travel times, and fuel consumption.

From these TRARR runs the required simulation and produces a main output file **OUT**.

As a modelling tool for evaluation of rural passing lanes and realignments, TRARR has proved to be an adequate package. However a number of potential drawbacks have been identified through practical experience, limiting TRARR's use for all rural simulation work in New Zealand. Koorey & Gu (2001) identified a number of existing concerns with TRARR. More detail is provided in their report but, in summary, these included:

- Inability to handle varying traffic flows down the highway, particularly due to major side roads.
- Inability to properly model the effects of restricted speed zones (such as small towns).
- Inability to model congested situations e.g. temporary lane closures or single-lane bridges.
- Difficulty in using field data for calibration, with no automatic calibration assistance built in.
- Difficulties creating and editing road data, particularly for planned new alignments.
- Limited ability to use the same tool to check for speed environment consistency and safety risks.
- Additional effort required in applying results to Transfund project evaluations.
- Lack of practical documentation for running typical TRARR applications in New Zealand.
- Lack of a modern interface (being a DOS-based program) and associated compatibility issues.

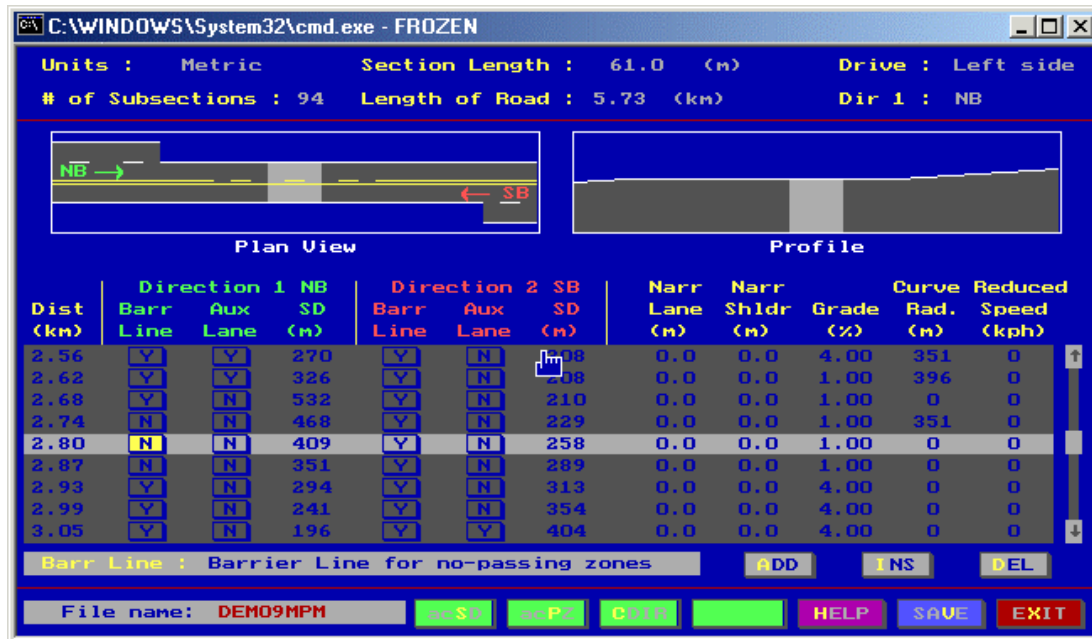
ARRB have stated that they are not planning further development of TRARR. What has perpetuated the use of TRARR to date has been the lack of feasible alternatives in New Zealand. There is therefore an incentive to identify or develop an alternative rural simulation tool for use in New Zealand with the desired improvements.

2.2 TWOPAS

The US software package TWOPAS (St John & Harwood 1986) is an alternative tool that appears very much worth investigating. Like TRARR, TWOPAS (“**TWO**-lane **PASS**ing”) is a microscopic simulation model of traffic on two-lane rural highways, first developed in the mid-1970s by Mid-West Research Institute for the US Federal Highway Administration (FHWA). TWOPAS was revised most recently in 1998 (Leiman *et al* 1998) to serve as the basis for updating the analysis procedures in the 2000 US Highway Capacity Manual (TRB 2000). This work included a (DOS-based) graphical interface UCBRURAL, developed by the University of Berkeley, California. Figure 2 shows a view of the UCBRURAL road editor.

As with TRARR, TWOPAS simulates the operation of each individual vehicle as it advances along the road, influenced by the route geometrics and the surrounding traffic situation. The following features are found in TWOPAS:

- Vehicle categories for passenger cars, recreational vehicles, and trucks, placed in 13 sub-types.
- Roadway specified in terms of horizontal curves, grades, vertical curves, and auxiliary lanes.
- Traffic controls specified by the user, particularly passing and no-passing zones.
- Traffic streams enter at each end of the simulated roadway generated in response to user-specified flow rate, traffic mix, and percent of traffic platooned.
- Variations in driver performance and preferences based on field data.
- Driver speed choices in unimpeded traffic based on user-specified distribution of desired speeds.
- Driver speed choices in impeded traffic based on a car-following model that simulates driver preferences for following distances, relative leader/follower speeds, and desire to pass the leader.
- Driver decisions concerning initiating passing manoeuvres in the opposing lane, continuing/aborting passing manoeuvres, and returning to normal lane are based on field data.
- Driver behaviour in passing/climbing/four-lane sections, including lane choice at beginning of added lane, lane changing/passing within added lanes and at lane drops, are based on field data.

Figure 2 Screenshot from TWOPAS 98 Road Editor

TWOPAS has been updated to incorporate changes in driver and vehicle characteristics and allow users to adjust for the effect on traffic operations of narrow lanes or shoulders and limited speed zones. Another major enhancement in the latest version is the capability to automatically generate available sight distance based on user specified offsets to sight obstructions.

TWOPAS uses just one input file to specify road and traffic parameters, as well as another file to hold default values such as vehicle performances. The simulation produces a very detailed output file, although an accompanying program, TWOSUM, is also available to produce more succinct and useable summary reports. The results can then be viewed within UCBRURAL.

While TWOPAS appears to be a promising alternative for TRARR, work is needed to confirm its validity and practicality for use here. Some further work is now continuing to improve TWOPAS even further, as part of the FHWA Interactive Highway Safety Design Model (IHSDM) programme (FHWA 2001). Improvements planned include allowance for vehicles turning on or off side roads, and a Windows interface. This ongoing development of TWOPAS makes it an attractive proposition to consider when compared with TRARR. An updated Windows version of TWOPAS should become available in the near future and recent beta versions have been obtained.

2.3 PARAMICS

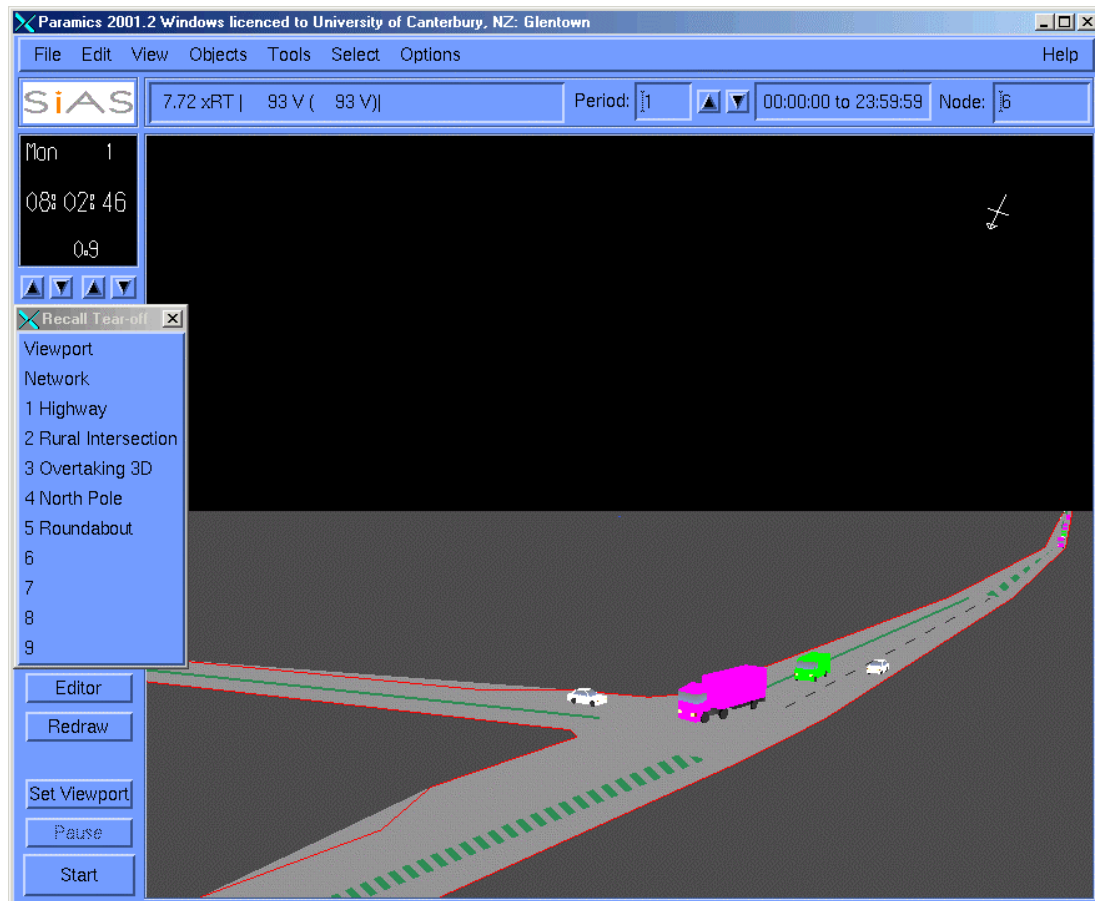
Much of the development of traffic models in recent times has focused on (often complex) urban and motorway networks. In the past, computing power has limited the ability to model these networks in great detail, resulting in “macro-simulation” packages that rely largely on speed-flow curves to determine link flows and efficiencies, e.g. SATURN by WS Atkins (UK). Now a number of software tools have been developed to take advantage of microsimulation techniques and one such tool is PARAMICS, produced by SIAS Ltd (Scotland).

PARAMICS simulates the individual components of traffic flow and congestion, and presents its output as a real-time visual display for traffic management and road network design. PARAMICS microsimulation is concerned with modelling individual vehicles for the duration of their journey through a network, with the route that a driver chooses not being predetermined, but depending on the network situation being encountered. The conditions in the model vary with time and drivers adapt their behaviour (e.g. route choice) in response to this. Thus a PARAMICS model is not a traditional network equilibrium model, but a dynamic model.

PARAMICS has been developed over more than ten years by UK traffic/transportation engineers. The name PARAMICS (“PARallel MICRoSimulation”) is a legacy of its initial focus on running

complex simulations on parallel processors. Earlier versions were only available for Unix systems, but a Windows PC version (running on a Unix X-Windows emulation) has been available for the last couple of years. PARAMICS 2001 Release 2 is the latest version, and improves on the editing abilities to simplify data entry (SIAS, 2001). Note that another PARAMICS package is marketed by Quadstone, following a split between the developers; this version was not investigated here. Figure 3 shows an example of 3D visual modelling within PARAMICS (models can also be viewed in 2D or batch-run without visualisation).

Figure 3 3D Screenshot from PARAMICS Simulation



Three interacting models applied at the same time govern the movement of individual vehicles in a PARAMICS model; car following, gap acceptance and lane changing. In addition, drivers have certain behavioural characteristics randomly assigned to them – aggression and awareness. These factors represent the characteristics of drivers that result in their different performances with regard to gap acceptance, car following and lane changing. Top speed, headway and lane usage are also influenced by these factors. Some simple vehicle dynamics are also taken into account, such as size, weight (e.g. for tonnage restrictions), acceleration and deceleration.

The road network is coded into the software in considerable detail and the success of the modelling depends somewhat on the accuracy of the road layout description. The input data include details of nodes, links and a large number of other details describing the network, such as number of lanes, parking or bus lanes, bus stop positions, traffic signal data, movement definitions and priorities at intersections etc. An important factor is how well the network is segmented into links, as PARAMICS ‘looks ahead’ only two links when determining the next action of each vehicle.

Although primarily aimed at urban networks and interurban motorways (where congestion effects tend to dictate vehicle speeds), it appears possible to apply PARAMICS or a similar model to a typical New Zealand rural highway, where geometric constraints may dictate. Some gradient and curve information can be entered and additional lanes and speed limits can also be specified. Laird and Nicholson (2000) developed the first urban PARAMICS model for New Zealand and were able

to show that this microsimulation software can be used to simulate local urban road conditions and driver behaviour accurately. Given the increasing use of these models in New Zealand for other applications, the relative merits of also applying them to rural highways are worth exploring.

2.4 Other Simulation Models

Both TRARR and TWOPAS are specifically designed for modelling rural highway links, and there is little else in the world currently developed for this application. HUTSIM from Finland's VTT is one other recent example, but the author has been unable to obtain sufficient information on this package (and it appears that recent focus has been on urban modelling).

Another well-established rural simulation model is the Swedish National Road and Traffic Research Institute (VTI) program (McLean 1989). Originally developed in the mid-1970's, VTI is part of a suite of programs for modelling traffic effects of roads. As with other models described above, VTI takes road geometry and vehicle performance inputs to predict overtaking, vehicle speeds and so on. The Swedish Centre for Traffic Simulation Research (CTR) has recently been granted funding to modernize the VTI model for Windows with animation (Andréasson 2001), and integrate it with a model for movements (trajectories and gap acceptance) in non-signalised intersections.

Apart from PARAMICS, a number of similar network micro-simulation packages have also been developed in recent years, such as AIMSUN (TSS, Spain), VISSIM (PTV, Germany), and DRACULA (ITS Leeds and WS Atkins, UK). AIMSUN has been used by Transit New Zealand for modelling the Auckland Motorway network (Hughes 1998). These packages could possibly also be tested in the future for their applicability to rural modelling, subject to their availability here.

3. Comparison of Models with Field Data Survey Information

A literature review identified a number of features of rural road sections (in terms of inputs or outputs) that would be desirable for the proposed software tools to model. These include:

- Free speed prediction, especially on grades and curves
- Vehicle interaction, bunching and overtaking
- The effects of additional lanes (e.g. passing lanes, four-laning, slow vehicle bays)
- The effects of speed limits and roadside developments
- Side road interaction with main road traffic
- The effect of constraints such as narrow roads, one-lane bridges, roadworks, etc
- Prediction of vehicle running costs
- The ability to assess conflicts between vehicles and to predict relative safety

The practical aspects of modelling rural highways, in terms of software usability, also need to be considered while testing the above scenarios.

To be able to test these scenarios against actual vehicle/driver behaviour, suitable sites were identified for field data collection. Sites ranged from spot locations (for speed surveys) to long sections more than 5km in length to assess changes in measures (such as speed and bunching) along the road. To minimise survey travel costs, sites were generally based around the principal researcher's location in Christchurch (Canterbury).

Sites were selected as much as possible so that one particular attribute could be examined in isolation of others. For example, a curve site should not have additional influences of gradients, speed limits, narrow lanes, side roads or passing lanes. By attempting to control for these other factors, the effects of each can be identified both in the field and in the corresponding models.

Each model was assessed for how easy it is to set up the required scenario and for how well it represents the true situation as shown by the field data. From this analysis, conclusions will be drawn as to the applicability of each model for New Zealand conditions.

3.1 TRARR

Currently, of the packages studied, TRARR is the best suited to quick setup of a road model, largely due to its use of geometry data similar to that collected by Transit New Zealand. The existing experience within New Zealand (including the author) of developing previous TRARR models makes for a familiarity that the other packages still have to cultivate.

Because of its previous use in New Zealand for rural modelling, little was needed to modify TRARR's input files for use in this study; the reader is referred to other reports such as Hoban *et al* (1991) for more detailed information. In particular, the vehicle and traffic stream parameters used for this study are those derived from the findings of Tate (1995) for New Zealand conditions.

Since the original RGDAS data collection in New Zealand, Transit New Zealand now collects and stores road geometry data in a different format, albeit a more useful one for relating to State Highway route positions. An automated database routine was developed to convert this data into an RGDAS format suitable for TRARR importing.

A series of customised batch programs enabled multiple road and traffic combinations to be modelled very quickly. Another custom-developed software tool was then used to extract the required information from the output files and combine them in a spreadsheet for analysis.

3.2 TWOPAS

The TWOPAS front-end, UCBRURAL, requires similar input data to that required by TRARR, making it easy to comprehend for many New Zealand analysts. In fact, this similarity stems from the legacy of UCBRURAL as a tool originally designed for running either TRARR or TWOPAS for research purposes, hence the need for presenting similar input data.

Like TRARR, TWOPAS defines its road data in terms of equal-length road sections. TWOPAS though allows flexibility in the section length used in a project to suit the analyst (between 16-1600m). Therefore more detailed geometry data could be incorporated than allowed for by TRARR (e.g. 20m sections), or longer lengths could be used for strategic planning purposes (e.g. 500m).

Currently TWOPAS does not allow an easy way to automatically import road geometry data into its front-end editor, because of the use of binary (machine-coded) data files. The actual TWOPAS engine itself uses a text-format file, so a procedure could be developed that automatically produced files of this format. However this is complicated by the fact that (unlike TRARR) the input file has no built-in explanation of each data item and all units are Imperial (e.g. mph, ft, etc). It appears that the new Windows version of TWOPAS will resolve these problems.

To counter this somewhat, one very useful facility that the UCBRURAL road editor has is the option to automatically repeat the geometric and cross-section attributes entered for a road section to all identical road sections following it. This enables data for long straights, gradients and curves to be quickly entered, 'element by element'.

A number of minor limitations are present in the TWOPAS simulations. Firstly sight distances are restricted to no more than 609m (2000 ft); it is not clear if this hinders the potential amount of overtaking that could be possible. Some New Zealand models may also find it difficult to comply with TWOPAS' minimum shoulder widths of 0.2m and maximum grades of 10%. The model is also limited to a maximum simulation time of 120 minutes (7200s). For a road with low volumes, insufficient vehicles could be modelled in that time; Tate (1995) suggests that at least 1000 vehicles need to be simulated, due to the random numbers used, to get a sufficient level of precision.

TWOPAS specifies five classes of car, four trucks classes and four classes of 'recreational vehicle' (RV). In comparison to the other models, this seems a bit limiting, particularly in terms of truck varieties. Although cars and light vehicles tend to dominate most rural traffic streams, the performance of trucks on the rest of the traffic is significant, and it may be worthwhile recoding some RV classes as truck types. Because of the minimal documentation regarding the vehicle parameters, no attempt has been made to date to produce a New Zealand-specific vehicle fleet for

TWOPAS. The mismatch with other common groupings such as TRARR's 18 categories and Transit NZ's 14-class scheme requires some thought about an appropriate matching process.

TWOPAS' ability to run multiple traffic simulations consecutively is a useful facility for quickly obtaining data over a wide range of volumes. It would be preferable however if multiple road files (e.g. project options) could also be run simultaneously, as is possible with TRARR 4. UCBRURAL then allows the results to be exported to a text file for easy importing into a spreadsheet. A more extensive array of report details can still be viewed in the corresponding *.OUT files if required.

3.3 PARAMICS

PARAMICS uses a series of simple text files to store different attributes of its network. For a typical rural highway, the most relevant ones are NODES, LINKS, CENTRES, and ANNOTATION. These files map out the geometry of the road sections in the model, with the latter providing any textual or graphical background information to display as well.

Default road link categories are provided to specify basic attributes of each link (speed, width, number of lanes, overtaking allowed, etc). The standard ones provided are geared towards urban and motorway networks, and are hence largely redundant for rural highways. For this project, a specific set of rural-based link categories were produced.

Road sections are defined as a series of straights and curves between fixed nodes. This "elements" approach differs from State Highway geometry data, which is stored at 10m intervals. Specifying individual links for each 10m section would greatly increase the complexity of the modelled network and limit the accuracy of built-in procedures such as forward sight-distance checking. The data therefore needs to be rationalised into longer tangents and curves along the highway.

An automated procedure was developed that took 10m geometry data, converted it into a series of geometric elements, and exported this information to the PARAMICS data files. The resulting plotted route identified the various "kinks" of the highway very well. However the ongoing errors inherent in the curvature estimation meant that the highway position got progressively further away from the true location. In terms of accuracy of modelling, this will probably not affect the results greatly as they are largely focused on localised road conditions.

The alternative approach is to use available mapping information to create the required highway alignment. Electronic aerial photos or topographic maps can be overlaid onto PARAMICS, and the highway alignment then manually created over the top. While this approach makes for easy setup of route alignments, care needs to be taken to ensure that horizontal curves reflect the true constraints and "kinks" on site. For a particularly winding alignment, this approach is also very laborious.

PARAMICS allows you to specify up to 512 vehicle types if desired. A graphical representation of each vehicle type can also be specified for visual modelling. For traditional PARAMICS models, the default types are categorised by both vehicle configuration (car, truck, etc) and journey purpose (home-to-work, leisure, etc). However, for rural modelling, vehicle performance is more important, particularly where highway geometry and open road speeds are involved. To obtain comparable measures with the other models, a vehicle set was created that replicates TRARR's 18 categories.

PARAMICS does not directly specify mean and standard deviation desired speeds for vehicle speed distributions. Free vehicle speeds in PARAMICS are controlled by a number of factors:

- The target speed for a certain vehicle type (generally representing the mean desired free speed)
- The default speed for the particular link category (generally equivalent to a speed limit)
- The link speed for a specific link (particularly curved links)
- The gradient of the link
- The transition between adjacent links (particularly when "kinked")

The methodology used appears to have a number of quirks not entirely suited to New Zealand highway modelling. For example, the assumption of mean speeds up to 20% above the speed limit does not match the typical NZ mean rural speed of approximately 102 km/h on long straights.

However this can be countered by using lower target vehicle-type speeds. It is also not clear how well observed field data fits with the variation and speed distribution used by PARAMICS. Comparisons between two-lane and four-lane roads with the same alignment and speed limits also give the counter-intuitive finding that mean free speeds are faster on the two-lane road.

As with other network models, zones are created at the end of each route and trip demands specified for each pair of origin/destination zones. For a simple linear highway, only two zones would be needed, but the method allows additional side roads to also be introduced if necessary. A number of different time periods can be modelled consecutively, each with a different traffic demand. This enables an entire rural traffic profile to be built up and modelled in one run if required.

A number of operational difficulties were encountered in the development of the various PARAMICS models. The most serious was that, on a regular basis when running a simulation, a vehicle would stop for no apparent reason and cause queues. This made collecting accurate simulation run data rather difficult, because the wayward vehicles had to be manually “destroyed” promptly. The problem was invariably at a mid-block node connection, but no obvious problems with respect to network geometry were apparent. Subsequent correspondence confirmed that this problem has been encountered before and SIAS are planning to fix the problem in the next release.

Other issues encountered seem to highlight the program’s origins in urban and motorway modelling. For example, rural crossroad approaches were automatically re-categorised as “Urban” links; it is not clear what the effect of this change is on vehicle behaviour. Similar problems exist when representing typical driver behaviour in situations like passing lane merges and right-turn bays at intersections.

PARAMICS sends results to a number of different files and directories, depending on the simulation run and type of data being collected. Hence, a more manual process was necessary to obtain the required information for subsequent analysis. It could be possible to develop a simple software tool to extract and collate the required information from each file in an efficient manner.

4. Comparison of Packages

Assessment of these simulation packages requires both the technical ability (model accuracy) and the functional ability (model usability) to be evaluated. A range of desired features under both categories have been identified and subsequently tested.

4.1 Accuracy of Prediction

Table 1 summarises the assessed correctness identified in each of the selected model features, after evaluation of each package in conjunction with field data and subjective experience. Note that although these assessments imply a reasonable level of model validity, calibration of a specific project with suitable field data is still recommended.

The table suggests that for most traditional rural modelling applications, TWOPAS is more robust than the alternatives, having benefited from the most recent rural highway research and development. PARAMICS shows acceptable performance in areas of more complex vehicle interaction, such as intersections and one-lane bridges, but does appear to need some tweaking of defaults to represent the behaviour of typical New Zealand rural drivers in many situations. TRARR still provides an adequate performance in the basic road alignment and passing lane assessment that has largely been its staple use in New Zealand over the past decade, but is limited beyond that.

One relevant aside is the issue of presentation of the outputs. PARAMICS clearly benefits in being able to demonstrate to (especially non-technical) audiences a visual representation of what is proposed; indeed, it can be crucial to “selling” a proposal. TRARR and TWOPAS are both limited internally to simple plots of key outputs like travel speeds and percent of vehicles following. However all packages allow to some degree the ability to take output data and represent it in external packages for customised reporting. For ongoing work, it may be feasible to develop data extraction tools to automate this process; this has been done in the past locally for TRARR.

Table 1 Assessment of Correctness of Selected Simulation Model Features

Rural Modelling Feature	TRARR 4	TWOPAS 98	PARAMICS '01
Curve Speed Prediction	22	22	22
Gradient Speed Prediction	1	22	22
Two-Lane Bunching/Overtaking	22	333	22
Passing Lane Overtaking	333	22	1
Speed-Flow Relationships	22	333	333
Speed Limits / Developments	1	22	22
Road Width Effects	-	22	1
Side Road Traffic	-	-	22
Delays at Constraints (roadworks, one-lane bridges)	-	-	22
Estimation of Fuel Consumption	?	?	?
Assessment of Safety / Conflicts	-	-	-

Key: 333 = excellent, 22 = fair, 1 = poor, ? = unknown, - = not available

4.2 Discussion

The ultimate test of any model is not whether various aspects of the model involve state-of-the-art theory or have user-friendly features. Rather, it is whether the simulation package can carry out an adequate evaluation of a particular project, in the most practical and accurate manner. It is likely that certain models will be better suited to some rural roading applications than others.

Table 2 sets out a suggested ranking of suitability of the models tested for a range of typical rural project applications. This is based on the investigations in this project as well as previous research and experience of the author. The likely ability of each package to adequately model the situation has been considered, as well as the ease of entering and extracting the required data. For example, curve and gradient speed prediction are likely to be of more significance in realignment projects than passing lane projects, where overtaking is more important. In some cases, only limited assessment has been possible to date; further investigation may suggest a change in rankings.

A list of known alternative methods of analysis is also presented in Table 2 for comparison. Full assessment of these was not possible in this project, but they include some relatively simpler (i.e. less costly and time-consuming) methods that may be appropriate at least at the scoping stage of many projects. Other network models similar to PARAMICS may also be appropriate.

It is notable that, while some project types are well served by modelling tools (e.g. passing lanes), others are still not well supported. Highway safety assessment in particular is not well covered at all by these kinds of models, and Koorey (2002) discusses some alternatives. For other areas, there may be scope for further research to develop suitable analysis tools for the industry.

Each of the three main models investigated appears to have particular strengths over the others. In the short term this suggests that it would be worth encouraging the use of different packages on projects, to obtain the most appropriate project evaluation and to develop experience by practitioners. Agencies like Transit New Zealand may have to take the lead in introducing the packages to the roading industry by holding technical workshops for various project applications.

In the long term it may be preferable to look at improving the “gaps” in the performance of some models so that they can cover a wider range of applications. This is particularly so for those areas where TRARR is currently the most suitable package, despite its older heritage. TRARR’s usability with New Zealand data often gives it the edge in some cases, despite less robust model outputs.

There are some caveats on the recommendations in Table 2:

- As with any modelling, sufficient field data is required to set up and calibrate the base model.
- New Zealand-based traffic and vehicle data should be used with overseas-based models. The TRARR defaults developed for New Zealand by Tate (1995) are a good base for other models.
- Any results derived from a computer model should be subjectively reviewed by independent means for reasonableness (e.g. expected order of magnitude).

Table 2 Suitability of Selected Simulation Models for various Rural Project Types(most suitable tool indicated in **bold**)

Project Type	TRARR	TWOPAS	PARAMICS	Alternative Methods
Simple (tack-on) Passing Lane	YYY	YYY	Y	PEM, TRB (2000)
Passing Opps Strategic Study	YY	YY	Y	TRB(2000), BCHF(2001)
Slow Vehicle Bay	YY	Y	-	Koorey & Gu (2001)
Two-Lane Highway Realignment	YYY	YY	-	-
Strategic Study Speed Profiles	Y	YY	-	-
Overtaking/Sight Distance Review	Y	Y	-	RGTRA, I-Spy
Four-Lane Highway Construction	Y	Y	YY	Network models?
Rural Intersection Assessment	-	Future?	Y	SIDRA
Expressway Interchange	-	-	YY	Network models?
Small Town Bypass	Y	Y	YY	Network models?
Shape Correction	-	-	-	-
Seal/Bridge Widening	-	Y	-	PEM
One-Lane Bridge Replacement	-	-	YY	Saunders (1988)
Temp. Traffic Control Delays	-	-	Y	-
Highway Safety Assessment	-	-	-	IHSDM, Koorey(2002)

Key: YYY = very suitable, YY = suitable, Y = may be suitable, - = not suitable

Hopefully, with further future development of TWOPAS and PARAMICS, these models will become even more useful for the various rural projects investigated in New Zealand. Feedback from practitioners in New Zealand back to the model developers will no doubt help the cause too.

5. Conclusions

Following field surveys at various highway locations, subsequent analysis and modelling showed:

- Most simulation models to date have been designed specifically for evaluation of efficiency issues (e.g. travel times, time spent following) rather than assessment of safety benefits.
- At present, most detailed rural simulation in New Zealand is carried out using TRARR. However a number of concerns and limitations have been identified, and no further upgrading is planned.
- TRARR still has a significant advantage in terms of familiarity to many New Zealand practitioners, and well-established support tools to enhance its ease of use for project evaluation.
- TWOPAS is similar to TRARR and ongoing development makes it an attractive long-term proposition. Its appropriateness and practicality for New Zealand use needs to be confirmed.
- TWOPAS generally has rural modelling features at least as comprehensive as TRARR. However it suffers at the moment from a limited means of bringing in road alignment data automatically.
- PARAMICS can model situations not traditionally provided for by rural simulation models. However it is more difficult to quickly set up and run a model and obtain the required outputs.
- There is still some question about the application of driver behaviour models in urban or motorway network micro-simulation packages to rural New Zealand roads.
- Each of the three main models investigated appears to have particular strengths over the others when considering different project applications, and merit further investigation and use.
- There are existing usability problems with both TWOPAS and PARAMICS that need to be addressed in future versions to make them more practical for rural highway use in New Zealand.

From this assessment, an initial ranking of suitability for different project types was produced.

6. Recommendations

The following items are recommended for further investigation or action.

- More work is needed to look at the potential for incorporating safety assessment into future development of existing "travel efficiency" simulation models.
- Undertake further surveys as described in the research survey plan to further validate the

accuracy of the various simulation tools, especially ‘before and after’ surveys of projects.

- Encourage the use of different simulation packages on rural roading projects, to obtain the most appropriate project evaluation and to develop experience by practitioners.
- Arrange suitable technical workshops introducing the various modelling options to the roading industry in New Zealand, and providing guidance on how to use them for project applications.
- Continue to monitor developments in models such as TWOPAS and PARAMICS, and liaise with the developers where possible to incorporate suitable features for New Zealand use.
- Subject to availability, investigate further the suitability for New Zealand rural roads of other simulation models identified overseas such as HUTSIM, VTI, AIMSUN, and DRACULA.

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